METHOD AND APPARATUS FOR SPRAYING

The present invention relates to a method and apparatus for low air pressure spraying. Particularly, but not exclusively, the invention is applicable to spray guns for the application of paint and like material surface treatments, particularly water-based paints.

The use of spray guns for application of paints is well known. However, it has been found that when water-based, high gloss paints are sprayed through a high pressure or conventional spray gun, the level of gloss is reduced. This is also true of the high volume-low pressure type of spray gun which operate at only 10psi air cap pressure.

Tests carried out at various pressures have shown that the loss of gloss is due to air bubbles rising to the surface of the paint as it dries. It has been found that the greater the pressure used to spray the paint, the more air bubbles appear. The cause of the bubbles is that dissolved air is being released from the water as the paint dries. The greater the air pressure when the paint is sprayed, the greater the volume of dissolved air and the greater the number of bubbles.

If the air pressure is low but the volume is high, gloss levels are reduced. To achieve the desired gloss levels with this type of paint it is necessary to design a spray gun that will operate at very low air pressures and very low air volumes. It must achieve acceptable levels of atomization, have sufficient energy to transfer the paint at an acceptable rate to the surface of the target, and expand the natural cone of spray into a useful fan pattern.

In the past, spray guns have used air pressures between 40 and 90 psi, and these high pressures cause a cushion of air to be formed on the surface of the product being treated. This cushion causes some of the sprayed material to bounce back and be displaced laterally by the following airflow to be lost in the surrounding air.

Accordingly, this type of spray gun is very inefficient. Rarely are transfer efficiencies greater than 40% and more often nearer 30%. The waste paint material produces unacceptable emissions of volatile organic compounds and leaves a solid residue which can remain floating in the air for some time. These can be highly toxic and damaging to the atmosphere and health. To overcome these problems, it is necessary to reduce the air pressure and air volume used in such guns. Therefore, the environmental requirements for an acceptable spray gun are similar to those required for achieving a good gloss in water-based paints.

If the air pressure is reduced on a spray gun that was originally designed for high pressure use, the turbulence and restrictions in internal air passages and the air cap cause a loss of air speed and a reduction in air volume. The result of this is low

paint transfer rates, poor atomization and an inferior paint finish. However, transfer efficiency is improved. If the air volume is increased while keeping the pressure low, the ratio of air to paint increases and the problems experienced with high pressure will return depending on the increase in volume.

Existing high pressure spray guns have been modified to operate at low pressures, but the complexity of the designs and the intricate interconnecting drilled passages do not permit good air flow. In an effort to overcome the poor performance, air cap ring gaps were increased, resulting in a substantial increase in air consumption. This type of spray gun has become known as the high volume-low pressure (HVLP) gun.

More specifically, in HVLP spray guns the means for actuating the control valves within the gun have had considerable shortcomings. For example, it is commonplace for the stem of the needle valve and its associated compression spring and housing to extend through the main air flow passage to the nozzle, thereby leading to significant restrictions in the air flow path.

Likewise, in order to provide a convenient means for actuating the stem of the air flow and fluid needle valves, the main nozzle of the apparatus is mounted on a forward projection of the apparatus so as to leave a free space to accommodate the arc of movement of the valve control trigger.

Moreover, since the same trigger operates both the liquid and air control valves, the progressive control from on to off operating characteristics of the air control valve can be restricted in certain operating

conditions where the liquid control valve has been manually adjusted to such a point that it affects the ability of the trigger to operate both valves simultaneously through the full range of movement.

The object of the present invention is to provide a method and apparatus for spraying paint and other surface treatment liquids, offering improvements in relation to one or more of the matters discussed above, or generally.

According to a first aspect of the invention there is provided an apparatus for spraying liquid surface treatment material, said apparatus having a housing, a liquid inlet for supply of the liquid surface treatment material, a gas inlet for supply of pressurised gas to be mixed with the liquid surface treatment material, an outlet nozzle through which the gas and liquid surface treatment material is sprayed, a control valve adapted to regulate the supply of the liquid surface treatment material to the outlet nozzle, a gas valve operable between an open position and a closed position, a first communicating passageway connecting said gas inlet to said gas valve, and a second communicating passageway connecting said gas valve to said outlet nozzle; wherein said second passageway is provided with a stepped portion therein so that a gas vortex is created therethrough.

Preferably, said second passageway is offset from said first passageway. Preferably, said second passageway is substantially conical in shape. Preferably, said second passageway includes an inlet and an outlet, wherein said passageway is tapered from said inlet to said outlet. Preferably, said taper is between 1 and 15°.

Preferably, said stepped portion of said second passageway comprises a ledge whose width tapers up to a maximum of 10% of the radius of said second passageway at the level of the stepped portion.

Preferably, said second passageway has a radius of curvature at said outlet so as to provide gas to the nozzle in a substantially horizontal direction.

Preferably, the longitudinal axis of said outlet nozzle extends across said second passageway. Preferably, the axis of symmetry of said ledge is offset from said longitudinal axis of said outlet nozzle, thereby inducing a vortex in the air flowing through said passageway.

According to a second aspect of the invention there is provided an apparatus for spraying liquid surface treatment material, said apparatus having a housing, a liquid inlet for supply of the liquid surface treatment material, a gas inlet for supply of pressurised gas to be mixed with the liquid surface treatment material, an outlet nozzle through which the gas and liquid surface treatment material is sprayed, a control valve adapted to regulate the supply of the liquid surface treatment material to the outlet nozzle, a gas valve operable between an open position and a closed position, a first communicating passageway connecting said gas inlet to said gas valve, and a second communicating passageway connecting said gas valve to said outlet nozzle; wherein said second passageway is axially offset from said first passageway and is substantially conical in shape, and wherein said second passageway includes an inlet and an outlet and is tapered from said inlet to said outlet at an angle of taper of between 1 and 15°.

Preferably the apparatus further comprises a trigger means, whereby said trigger means is adapted to operate both of said control valve and said gas valve.

Preferably, said gas valve is an axially-sliding piston valve. Preferably, said control valve is a liquid control needle valve.

Preferably, said outlet nozzle is controlled by said liquid control needle valve.

Preferably, said piston valve produces an annular air jet in said second passageway. The piston valve may be tapered or parallel. In addition, an air control valve stem is provided which is connected to the piston valve and operated by said trigger means.

Preferably, said piston valve comprises inner and outer co-axial apertured sleeves, wherein said inner sleeve is located within said outer sleeve and is rotatably adjustable relative to said outer sleeve.

Preferably, the liquid control needle valve is controlled by said trigger means via an axially-sliding sleeve or slipper member situated on a rearward portion of the housing. Preferably, it is also provided with a rotational flow adjustment means to adjust the flow rate of the liquid.

Preferably, said flow adjustment means comprises a stem member, a rotational adjuster, and a return spring, said stem member being threaded at its rearmost extremity to accept the rotational adjuster. Preferably, said stem member is actuated externally by the trigger means, and is returned to its initial position by a return spring.

Preferably, the apparatus further comprises a regulating valve and a pair of side jets, whereby the spray pattern of the outlet nozzle is regulated by said regulating valve, and said side jets are utilised to regulate said spray pattern.

Preferably, the needle valve is supplied with the paint or material surface treatment liquid by a pressurized material supply connector which distributes the material via a radial port to said needle valve. Alternatively, the material may be introduced to the apparatus from a gravity liquid reservoir fitted to the uppermost aspect of the apparatus via a radial port.

According to a third aspect of the present invention, there is provided a method of spraying a fluid onto a surface, said method comprising the steps of:

supplying a liquid to be sprayed into a liquid inlet of a spray apparatus;

supplying a pressurised gaseous propellant into a gas inlet of said spray apparatus;

passing said gaseous propellant through a communicating passageway from said gas inlet to an outlet nozzle;

accelerating said gaseous propellant by creating a gas vortex as said propellant passes through said communicating passageway;

passing said accelerated propellant through an outwardly tapering portion of the communicating passageway to further accelerate the vortex and supply the propellant to the outlet nozzle in the form of an annular gas jet; and

spraying said liquid onto a surface by mixing said liquid and said annular gas jet at said nozzle.

Preferably, said passageway comprises an upper portion

and a lower portion, wherein said upper portion is axially offset from said lower portion and is substantially conical in shape. Preferably, said upper portion of said passageway includes an inlet and an outlet and is tapered from said inlet to said outlet at an angle of taper of between 1 and 15°.

Preferably, the mixing of said liquid and said annular gas jet is controlled by a trigger valve mechanism on said spray apparatus. Preferably, said trigger valve mechanism comprises:

a gas valve operable between an open position and a closed position;

a control valve adapted to regulate the supply of the liquid to be sprayed; and

a trigger means;

whereby said trigger means is adapted to operate both of said gas and control valves.

Preferably, said control valve is a liquid control needle valve. Preferably, said gas valve is an axially-sliding piston valve. Preferably said piston valve comprises an inner apertured sleeve and an outer apertured sleeve, said inner and outer sleeves being co-axial, and wherein said inner sleeve is located within said outer sleeve and is rotatably adjustable relative to said outer sleeve.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which :-

Figure 1 shows a first embodiment of a spray gun according to the present invention;

Figure 2 shows a section through the spray gun of

Figure 1 having pressure feed and offset air passages;

Figure 3 shows a second embodiment of a spray gun according to the present invention;

Figure 4(a) shows a section through the spray gun of Figure 3 having offset air passages and a tapered upper air passage;

Figure 4(b) is a sectional view along line "A-A" of Figure 4(a);

Figure 4(c) is a sectional view along line "B-B" of Figure 4(a), showing the stepped portion of the upper air passage;

Figure 5 shows a third embodiment of a spray gun according to the present invention;

Figure 6(a) shows a section through the spray gun of Figure 5;

Figure 6(b) shows the component parts of the piston valve of the spray gun of Figures 5 and 6(a); and

Figure 6(c) shows a sectional view along line "VI-VI" of Figure 6(a).

As shown in Fig 1, a first embodiment of a spray apparatus 10 comprises a body or housing 12 having a nozzle 14, an operating trigger 40, and a regulating valve 52. Nozzle 14 is secured to the housing 12 by a threaded ring 11.

Figure 2 shows a section view through the spray gun which shows the components of the apparatus 10 in more

detail. The apparatus 10 has an air supply connection 16, a pressurized material supply connection 18, an air control valve stem 20, and a liquid control valve 22. It will be noticed that in this embodiment, and each of the subsequent embodiments described herein, the air supply connection 16 and material supply connection 18 and their respective supply passages are located in the handle portion of the apparatus 10. By locating both supply connections 16,18 in the handle portion, the apparatus 10 can be packaged in a more compact manner than prior art apparatus. Furthermore, by being located in the handle the supply passages are free from the internal restrictions which can hamper the performance of known apparatus.

A tapered piston valve 23 controls the supply of air to the nozzle 14 in order to regulate the spray pattern. The nozzle 14 provides a central jet 15 controlled by the liquid control needle valve 22, and an annular air jet 28 controlled by the piston valve 23. The air control valve stem 20 connects to an axially-sliding piston 24 to effect progressive throttling of the air flow. The stem 20 is pushed by an operating trigger 40.

The air supply connection 16 is coupled to a compressor (not shown) which provides air under pressure to the air supply connection 16. Connection 18 is supplied by a reservoir (not shown) containing paint or like material to be sprayed.

The liquid control needle valve 22 has a rotational adjuster 44 and is controlled by the trigger 40 through a sleeve member 46 which slides on a rearward portion 48 of the housing 12. The trigger 40 acts on the sleeve 46 by way of a flange (not shown) on the sleeve

46, thereby opening the needle valve 22 to allow liquid to pass through.

A regulating valve 52 is positioned whereby the jet 15 produced by nozzle 14 is regulated from a natural cone to a fan pattern by air from side jets 17.

The air passage 38 connects the air supply connection 16 with the piston valve 23. The air control valve stem 20 controls the air flow through a pair of offset passages 38 and 39, where the lower passage 38 and the upper passage 39 are offset to create a vortex within the upper passage 39, thereby accelerating the gas flow through said upper passage 39. A return spring 25 is also provided in order to return the piston 24 and stem 20 to their extended position when released. The piston valve 23 has two apertured rotational sleeves 26 which can be adjusted by a lever 21 to either line up, close off or partially close the apertures, thereby increasing or decreasing the vortex in the passage 39. Thus, the pressure in the gun can be regulated to offer variable pressure sprays. A more detailed description of the operation of the piston valve 23 is given later.

The liquid control valve needle 22 has a stem member 42 which passes through sleeve member 46 and is threaded at its rearmost extremity to accept the rotational adjuster 44. The rotational adjuster 44 allows fine position adjustment of the fluid control needle 22. Trigger 40 actuates the needle member 22 externally of the housing 12. An internal return spring (not shown) returns the needle 22 to its rest position. Liquid to be sprayed is fed to the needle valve 22 from connection 18 via a radial port 56.

Figure 3 shows a second embodiment of a spray gun

apparatus 10 according to the present invention. Externally, the second embodiment appears similar to the apparatus of the first embodiment. However, the sectional views of Figures 4(a)-(c) highlight the difference between the two embodiments.

Figures 4(a)-(c) show views of the second embodiment of the spray gun 10 in which upper air passage 39 has been modified to assist the creation of the vortex within the upper passage 39. Figure 4(b) shows the tapering of the upper passage 39 to assist the acceleration of the gas therein. The best acceleration results have been produced when the tapering is between 0 and 10°. Figure 4(c) shows the cross-section B-B of the upper passage 39 at its inlet, wherein a stepped portion 50 is provided. For the most effective vortex, the stepped portion 50 should encompass approximately 10% of the circumference of the upper passage 39.

The vortex is created in the upper passage 39 as the gas passes through the inlet of upper passage 39 over the stepped portion 50, which can be best seen in Fig 4(b). As the gas passes over the stepped portion 50, the increased area causes the gas to swirl in the passage, thereby creating the vortex which produces a gas acceleration upwards through the upper passage 39. The tapering of the upper passage 39 ensures that the vortex is sustained until it reaches the outlet of the upper passage 39 at nozzle 14.

As with each of the embodiments described herein, the liquid control valve needle 22 passes through the uppermost chamber 51 of the upper passage 39. This is best seen in Figure 4(b), where the valve 22 passes directly through the chamber 51 in such a way as to not hinder the vortex created in the upper passage 39.

Thus, the vortex flows through the chamber 51 relatively unhindered by the valve 22 as the gas flows around the outside of the valve 22, and the vortex is not destroyed by the valve 22.

Aside from the amendments to the passage 39, this embodiment of the spray gun 10 is constructed and operated substantially in the same manner as the spray gun 10 of figure 1.

The third and final of the preferred embodiments described is shown in Figures 5 and 6(a)-(c). Again, externally, the spray gun 10 is similar in appearance to the other embodiments, with the majority of the components previously described above being used. However, the third embodiment differs in the operation of the piston valve assembly 23 which produces the vortex.

The use of a pair of apertured sleeves 26a,26b within the piston valve assembly 23 was first discussed in the description of the first embodiment above. However, the individual components of the piston valve assembly 23 are best seen in Figure 6(b). The valve assembly 23 consists of an apertured outer sleeve 26b and an apertured inner sleeve 26a, and each of the sleeves 26a,26b has a pair of apertures 61,62. On each sleeve 26a,26b, the apertures 61,62 are located diametrically opposite one another, thereby permitting gas to pass through the sleeves 26a,26b unhindered.

Figure 6(a) shows the manner in which the various components of the valve assembly 23 co-operate. The inner sleeve 26a is located inside the outer sleeve 26b, with the apertures 61,62 of the two sleeves 26a,26b being axially aligned to allow gas to pass

directly through the sleeves 26a,26b. The inner sleeve 26a is fitted with a lever 21 so that the inner sleeve 26a may be rotated relative to the outer sleeve 26b. A return spring 25 is located within the sleeves 26a,26b with a piston 24 positioned thereon. The piston 24 receives the spring 25 on one end 24a and an air control valve stem 20 on the other end 24b. The stem 20 has a flange 20a which locates in the second end 24b of the piston so that the stem 20 may act on the piston 24.

Thus, in order to operate the piston valve assembly 23, the trigger 40 is pulled towards the housing 12 of the apparatus 10. As the trigger 40 is pulled, it acts on the valve stem 20 which in turn acts on the piston 24. The action of the trigger 40 thus pushes the piston 24 away from the air passages, thereby permitting the gas to pass through the valve assembly 23 by way of the aligned apertures 61,62 in the inner and outer sleeves 26a,26b. When the trigger 40 is released, the spring 25 pushes the piston 24, stem 20, and trigger 40 back to their original positions, and gas can therefore no longer pass through the valve assembly 23.

Figure 6(c) shows how the alignment of the apertures 61,62 on the inner and outer sleeves 26a,26b can be varied to improve the vortex generation in the upper air passage 39. The lever 21 can be rotatably adjusted in order to rotate the inner sleeve 26a relative to the fixed outer sleeve 26b. Thus, as is seen in Figure 6(c), the apertures 61,62 can be offset from each other. This offsetting of the apertures 61,62 creates a lip portion 63, where a portion of the inner sleeve 26a partly blocks the aperture 61 of the outer sleeve 26b. Thus, the gas flowing through the valve assembly 23 is disrupted thereby creating the vortex in the

upper passage 39 of the apparatus 10.

In use, each of the embodiments is operated as follows: The reservoir of material to be sprayed delivers the material to central jet 15 under the control of needle valve 22 where it is mixed with air delivered via air passages 38 and 39. The operation of the gun is initiated by trigger 40 operating air control valve stem 20 and liquid control valve 22.

The present invention provides a method and apparatus for spraying that addresses the limitations and inefficiencies of prior spray guns. As it may operate at pressures as low as 1.5psi in the air cap and at air volumes as low as 4cfm, energy savings are achieved. The very low pressures allow a very high transfer efficiency to be achieved which is an added advantage when used with paints containing volatile organic compounds.

The present invention permits the trigger 40 to operate the air control valve 23 and the fluid control valve 22 simultaneously, without restricting the operation of either, regardless of the adjustment of the other. The stems of both the fluid control needle valve 22 and air control piston valve 23 operate in parallel to each other, yet independently of each other.

The above permits a straight, unobstructed, large diameter air passage 38 to the air valve 23 while also permitting a short, straight air passage 39 to the air cap 52 and a large diameter fluid passage.

In addition, by offsetting the air passages 38,39, gas acceleration may be achieved by means of a vortex created by the gas passing through these passages

38,39. With gas acceleration in the head portion of the apparatus 10, the increased speed of the gas created by the vortex leads to an increase in air speed at the nozzle 14 and thereby an increase in material sprayed by the gun. Therefore, although gas is introduced to the apparatus 10 from a compressor at relatively low pressure, by having the air passages 38,39 arranged in the offset position a gas acceleration is achieved with a consequential increase in efficiency at the nozzle 14. Moreover, the gas acceleration is further improved by the provision of a pair of adjustable, apertured sleeves 26a,26b which can either increase or decrease gas flow into the vortex from the air valve 23 depending on the alignment of the apertures 61,62.

The features of the present invention:

- i) reduce the compressed air volume required;
- ii) reduce the pressure of said compressed air;
- iii) reduce energy losses;
- iv) improve exit air speed;
- v) increase depression at the fluid nozzle; and
- vi) reduce resistance to fluid flow.

The internal surface area of the air passages is approximately 50% less than a representative selection of spray guns currently available.

The trigger to air cap air passage length is 75% less than with the representative selection.

Total air passage length is approximately 40% less than with the representative selection.

Input air pressure is 75% lower than the average of the representative selection.

Air volume required is approximately 50% lower than the average of the representative selection.

Depression at the fluid nozzle is approximately 30% greater than the representative selection.

These and other improvements and modifications can be incorporated without departing from the scope of the invention.